Comments on FEC proposals for IEEE 802.16.1 Air Interface

IEEE 802.16 Presentation Submission Template (Rev. 8)

Document Number: 802.16.1pp-00/32

DATE: 2000-07-12

Source:

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Venue:

This doc is to be presented for discussion in 802.16.1 FEC Ad Hoc meeting session #8

Base Documents:

802.16.1pc-00/32r1

Purpose:

Summarizing results and Recommendations for FEC considerations

General Remarks

- Four distinct FEC schemes were introduced for DL:
  - RS + CC, RS : mode A of draft PHY
  - RS + BC, RS: mode B of draft PHY
  - BTC : Hamming PC, Parity PC
- Three basic FEC schemes were introduced for UL:
  - RS, RS+BC
  - BTC (several variants)

Down Link FEC

- DL characteristics:
  - multilevel modulations:4-16-64 QAM
  - fixed\adaptive modulations
  - support continuous or burst modes
  - high code rate (0.6 to 0.9) and large blocks are desired. Should decide if ~0.5 is required
  - fixed\adaptive (flexible) code rate ?!
  - CRC !?
  - Large Interleaver is necessary MODE A

General remarks (cont.)

- UL characteristics:
  - support high order modulations:4-16-64 QAM
  - burst modes only
  - low\medium code rate (0.4 to 0.7) is expected
  - short blocks (5,14,18 bytes etc.) are expected (signaling purpose)
  - CRC !?
  - NO Interleaver

DL and UL have different characteristics

TABL1: BTC vers. RS comparison

note: RS analysis is semi-analytic UB meeting

BTC both H/W finite word and analytic, UB is not met

	Eb/N0 dB E-6 QPSK	Eb/N0 dB E-9 QPSK	Eb/N0 dB E-6 64QAM	Eb/N0 dB E-9 64QAM	Ref.
RS(204,188) r=0.9216	6.99	7.69	14.90	15.68	QH
RS(138,128) r=0.9275	7.36	8.25	15.33	16.30	QH
RS(144,128) r=0.8889	6.87	7.60	14.75	15.58	QH
RS(69,53) r=0.7681	6.84	7.67	14.65	15.58	QH
BTC, 0.88	3.8	4.2	11.1	11.4	Wil
BTC, 0.79	3.5	4.3	11	12	RW

Comments on RS vers. BTC

- BTC performs >3dB better than RS only at the same rate
- BTC requires larger block sizes to achieve high rate and high coding gain. **(relevant to DL modes).**
- shortening BTC allows shorter block size with reduced rate

  --> coding gain remains almost constant
- shortening RS keeping t=8 is not a good practice for short block codes used for signaling **(relevant to UL modes)**

Conclusions:

RS only in DL variants as proposed in the PHY draft are 3dB inferior to BTC @ same code rate. BTC can further be improved to approach Union Bound.

TABL2: BTC vers. RS+BC comparison

note: RSP analysis is semi-analytic UB meeting

BTC results are H/W finite word, far from UB

	Eb/N0 dB E-6 QPSK	Eb/N0 dB E-9 QPSK	Eb/N0 dB E-6 64QAM	Eb/N0 dB E-9 64QAM	Ref.
RSP(204,188) r=0.8192	5.55	6.16			QH, R
RSP(138,128) r=0.8245	5.90	6.62			QH,R
RSP(144,128) r=0.79	5.48	6.11			QH,R
RSP(69,53) r=0.6828	5.54	6.23			QH,R
BTC, 0.88	3.8	4.6	11.1	11.4	Wil
BTC, 0.79	3.5	4.3	11	12	RW

RS+BC vers BTC

- Gray mapping and soft decision decoders for both cases
- MODE B has also (40,32) + RS and (48,32) + RS.

  But, latest contribution pc-00/31 considers only RSP codes and

  concatenation of RS + (24,16).
- Performance of RSP were simulated - (for q=3 add 0.3 dB)

BTC performs ~2dB better than RSP @same code rate

- Further analysis is required to compare DL low code rates variants of RS+BC vers. BTC. Much better flexibility to BTC since large codes for MODE A (see pc-00/35) and small codes for MODE B are supported.
- Only partial UB analysis related with QPSK is available with current contributions (RSP, RSV and BTC)

TABL3: BTC vers. RS+CC comparison

two semi-analytic “RSV” UB meeting given

BTC results are H/W finite word, far from UB

	Eb/N0 dB E-6 QPSK	Eb/N0 dB E-9 QPSK	Eb/N0 dB E-6 64QAM	Eb/N0 dB E-9 64QAM	Ref.
RS(204,188)+V(1/2) r=0.461 BTC, r=0.45	2.56? 3.4 1.5	2.95? 3.6 1.8			QH FL Wil
RS(204,188)+V(2/3) r=0.614	3.11? 3.75	3.48? 4.0			QH FL
RS(204,188)+V(3/4) r=0.691	3.58? 4.125	3.95? 4.50			QH FL
RS(204,188)+V(5/6) r=0.768	4.15? 4.75	4.50? 5.0			QH FL
RS(204,188)+V(7/8) r=0.806	4.55? 5.125	4.89? 5.375			QH FL
BTC, r=0.79 BTC, r=0.88	3.5 3.8	4.3 4.0?	11	12	RW Wil

BTC vers. RSV

- RSV analysis of QH is over optimistic both QH and FL give non realistic slop for BER VERS. Eb/N0 curves.
- Effective RSV Block size should be I*K, where I=12 is inteleaver depth
- fair comparison between BTC and RSV @ same code rate implies at least 1.5dB better performance
- **Both RSV and BTC are concatenation of two codes. However, BTC represents much better concatenation strategy: replacing Interleaving with large codes, SISO**